

Measurement of the Branching Fractions and CP Asymmetries of $B^- \rightarrow D_{(CP)}^0 K^-$ Decays with the **BABAR** Detector

The **BABAR** Collaboration

February 7, 2008

Abstract

We present a study of $B^- \rightarrow D_{(CP)}^0 K^-$ decays, where $D_{(CP)}^0$ is reconstructed in flavor ($K^- \pi^+$), CP -even ($K^- K^+, \pi^- \pi^+$) and CP -odd ($K_s^0 \pi^0$) eigenstates, based on a sample of about 214 million $\Upsilon(4S) \rightarrow B\bar{B}$ decays collected with the **BABAR** detector at the PEP-II e^+e^- storage ring. Along with the Cabibbo-suppressed $B^- \rightarrow D_{(CP)}^0 K^-$ decays we reconstruct also the Cabibbo-favored $B^- \rightarrow D_{(CP)}^0 \pi^-$ decays. We measure the double ratio of branching fractions

$$\begin{aligned} R_+ &\equiv \frac{\mathcal{B}(B^- \rightarrow D_{CP+}^0 K^-)/\mathcal{B}(B^- \rightarrow D_{CP+}^0 \pi^-)}{\mathcal{B}(B^- \rightarrow D^0 K^-)/\mathcal{B}(B^- \rightarrow D^0 \pi^-)} \\ &= 0.87 \pm 0.14(\text{stat}) \pm 0.06(\text{syst}), \end{aligned}$$

$$\begin{aligned} R_- &\equiv \frac{\mathcal{B}(B^- \rightarrow D_{CP-}^0 K^-)/\mathcal{B}(B^- \rightarrow D_{CP-}^0 \pi^-)}{\mathcal{B}(B^- \rightarrow D^0 K^-)/\mathcal{B}(B^- \rightarrow D^0 \pi^-)} \\ &= 0.80 \pm 0.14(\text{stat}) \pm 0.08(\text{syst}), \end{aligned}$$

and the CP asymmetries

$$\begin{aligned} A_{CP+} &\equiv \frac{\mathcal{B}(B^- \rightarrow D_{CP+}^0 K^-) - \mathcal{B}(B^+ \rightarrow D_{CP+}^0 K^+)}{\mathcal{B}(B^- \rightarrow D_{CP+}^0 K^-) + \mathcal{B}(B^+ \rightarrow D_{CP+}^0 K^+)} \\ &= 0.40 \pm 0.15(\text{stat}) \pm 0.08(\text{syst}) \end{aligned}$$

$$\begin{aligned}
A_{CP-} &\equiv \frac{\mathcal{B}(B^- \rightarrow D_{CP-}^0 K^-) - \mathcal{B}(B^+ \rightarrow D_{CP-}^0 K^+)}{\mathcal{B}(B^- \rightarrow D_{CP-}^0 K^-) + \mathcal{B}(B^+ \rightarrow D_{CP-}^0 K^+)} \\
&= 0.21 \pm 0.17(\text{stat}) \pm 0.07(\text{syst}).
\end{aligned}$$

All results are preliminary.

Submitted to the 32nd International Conference on High-Energy Physics, ICHEP 04,
 16 August—22 August 2004, Beijing, China

Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309

Work supported in part by Department of Energy contract DE-AC03-76SF00515.

The *BABAR* Collaboration,

B. Aubert, R. Barate, D. Boutigny, F. Couderc, J.-M. Gaillard, A. Hicheur, Y. Karyotakis, J. P. Lees,
V. Tisserand, A. Zghiche

Laboratoire de Physique des Particules, F-74941 Annecy-le-Vieux, France

A. Palano, A. Pompili

Università di Bari, Dipartimento di Fisica and INFN, I-70126 Bari, Italy

J. C. Chen, N. D. Qi, G. Rong, P. Wang, Y. S. Zhu

Institute of High Energy Physics, Beijing 100039, China

G. Eigen, I. Ofte, B. Stugu

University of Bergen, Inst. of Physics, N-5007 Bergen, Norway

G. S. Abrams, A. W. Borgland, A. B. Breon, D. N. Brown, J. Button-Shafer, R. N. Cahn, E. Charles,
C. T. Day, M. S. Gill, A. V. Gritsan, Y. Groysman, R. G. Jacobsen, R. W. Kadel, J. Kadyk, L. T. Kerth,
Yu. G. Kolomensky, G. Kukartsev, G. Lynch, L. M. Mir, P. J. Oddone, T. J. Orimoto, M. Pripstein,
N. A. Roe, M. T. Ronan, V. G. Shelkov, W. A. Wenzel

Lawrence Berkeley National Laboratory and University of California, Berkeley, CA 94720, USA

M. Barrett, K. E. Ford, T. J. Harrison, A. J. Hart, C. M. Hawkes, S. E. Morgan, A. T. Watson
University of Birmingham, Birmingham, B15 2TT, United Kingdom

M. Fritsch, K. Goetzen, T. Held, H. Koch, B. Lewandowski, M. Pelizaeus, M. Steinke

Ruhr Universität Bochum, Institut für Experimentalphysik 1, D-44780 Bochum, Germany

J. T. Boyd, N. Chevalier, W. N. Cottingham, M. P. Kelly, T. E. Latham, F. F. Wilson
University of Bristol, Bristol BS8 1TL, United Kingdom

T. Cuhadar-Donszelmann, C. Hearty, N. S. Knecht, T. S. Mattison, J. A. McKenna, D. Thiessen
University of British Columbia, Vancouver, BC, Canada V6T 1Z1

A. Khan, P. Kyberd, L. Teodorescu

Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom

A. E. Blinov, V. E. Blinov, V. P. Druzhinin, V. B. Golubev, V. N. Ivanchenko, E. A. Kravchenko,
A. P. Onuchin, S. I. Serednyakov, Yu. I. Skovpen, E. P. Solodov, A. N. Yushkov
Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia

D. Best, M. Bruinsma, M. Chao, I. Eschrich, D. Kirkby, A. J. Lankford, M. Mandelkern, R. K. Mommsen,
W. Roethel, D. P. Stoker
University of California at Irvine, Irvine, CA 92697, USA

C. Buchanan, B. L. Hartfiel

University of California at Los Angeles, Los Angeles, CA 90024, USA

S. D. Foulkes, J. W. Gary, B. C. Shen, K. Wang

University of California at Riverside, Riverside, CA 92521, USA

D. del Re, H. K. Hadavand, E. J. Hill, D. B. MacFarlane, H. P. Paar, Sh. Rahatlou, V. Sharma
University of California at San Diego, La Jolla, CA 92093, USA

J. W. Berryhill, C. Campagnari, B. Dahmes, O. Long, A. Lu, M. A. Mazur, J. D. Richman, W. Verkerke
University of California at Santa Barbara, Santa Barbara, CA 93106, USA

T. W. Beck, A. M. Eisner, C. A. Heusch, J. Kroseberg, W. S. Lockman, G. Nesom, T. Schalk,
B. A. Schumm, A. Seiden, P. Spradlin, D. C. Williams, M. G. Wilson
University of California at Santa Cruz, Institute for Particle Physics, Santa Cruz, CA 95064, USA

J. Albert, E. Chen, G. P. Dubois-Felsmann, A. Dvoretskii, D. G. Hitlin, I. Narsky, T. Piatenko,
F. C. Porter, A. Ryd, A. Samuel, S. Yang
California Institute of Technology, Pasadena, CA 91125, USA

S. Jayatilleke, G. Mancinelli, B. T. Meadows, M. D. Sokoloff
University of Cincinnati, Cincinnati, OH 45221, USA

T. Abe, F. Blanc, P. Bloom, S. Chen, W. T. Ford, U. Nauenberg, A. Olivas, P. Rankin, J. G. Smith,
J. Zhang, L. Zhang
University of Colorado, Boulder, CO 80309, USA

A. Chen, J. L. Harton, A. Soffer, W. H. Toki, R. J. Wilson, Q. Zeng
Colorado State University, Fort Collins, CO 80523, USA

D. Altenburg, T. Brandt, J. Brose, M. Dickopp, E. Feltresi, A. Hauke, H. M. Lacker, R. Müller-Pfefferkorn,
R. Nogowski, S. Otto, A. Petzold, J. Schubert, K. R. Schubert, R. Schwierz, B. Spaan, J. E. Sundermann
Technische Universität Dresden, Institut für Kern- und Teilchenphysik, D-01062 Dresden, Germany

D. Bernard, G. R. Bonneaud, F. Brochard, P. Grenier, S. Schrenk, Ch. Thiebaux, G. Vasileiadis, M. Verderi
Ecole Polytechnique, LLR, F-91128 Palaiseau, France

D. J. Bard, P. J. Clark, D. Lavin, F. Muheim, S. Playfer, Y. Xie
University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom

M. Andreotti, V. Azzolini, D. Bettoni, C. Bozzi, R. Calabrese, G. Cibinetto, E. Luppi, M. Negrini,
L. Piemontese, A. Sarti
Università di Ferrara, Dipartimento di Fisica and INFN, I-44100 Ferrara, Italy

E. Treadwell
Florida A&M University, Tallahassee, FL 32307, USA

F. Anulli, R. Baldini-Ferroli, A. Calcaterra, R. de Sangro, G. Finocchiaro, P. Patteri, I. M. Peruzzi,
M. Piccolo, A. Zallo
Laboratori Nazionali di Frascati dell'INFN, I-00044 Frascati, Italy

A. Buzzo, R. Capra, R. Contri, G. Crosetti, M. Lo Vetere, M. Macri, M. R. Monge, S. Passaggio,
C. Patrignani, E. Robutti, A. Santroni, S. Tosi
Università di Genova, Dipartimento di Fisica and INFN, I-16146 Genova, Italy

S. Bailey, G. Brandenburg, K. S. Chaisanguanthum, M. Morii, E. Won
Harvard University, Cambridge, MA 02138, USA

R. S. Dubitzky, U. Langenegger

Universität Heidelberg, Physikalisches Institut, Philosophenweg 12, D-69120 Heidelberg, Germany

W. Bhimji, D. A. Bowerman, P. D. Dauncey, U. Egede, J. R. Gaillard, G. W. Morton, J. A. Nash,
M. B. Nikolic, G. P. Taylor

Imperial College London, London, SW7 2AZ, United Kingdom

M. J. Charles, G. J. Grenier, U. Mallik

University of Iowa, Iowa City, IA 52242, USA

J. Cochran, H. B. Crawley, J. Lamsa, W. T. Meyer, S. Prell, E. I. Rosenberg, A. E. Rubin, J. Yi
Iowa State University, Ames, IA 50011-3160, USA

M. Biasini, R. Covarelli, M. Pioppi

Università di Perugia, Dipartimento di Fisica and INFN, I-06100 Perugia, Italy

M. Davier, X. Giroux, G. Grosdidier, A. Höcker, S. Laplace, F. Le Diberder, V. Lepeltier, A. M. Lutz,
T. C. Petersen, S. Plaszczynski, M. H. Schune, L. Tantot, G. Wormser
Laboratoire de l'Accélérateur Linéaire, F-91898 Orsay, France

C. H. Cheng, D. J. Lange, M. C. Simani, D. M. Wright

Lawrence Livermore National Laboratory, Livermore, CA 94550, USA

A. J. Bevan, C. A. Chavez, J. P. Coleman, I. J. Forster, J. R. Fry, E. Gabathuler, R. Gamet,
D. E. Hutchcroft, R. J. Parry, D. J. Payne, R. J. Sloane, C. Touramanis
University of Liverpool, Liverpool L69 72E, United Kingdom

J. J. Back,¹ C. M. Cormack, P. F. Harrison,¹ F. Di Lodovico, G. B. Mohanty¹
Queen Mary, University of London, E1 4NS, United Kingdom

C. L. Brown, G. Cowan, R. L. Flack, H. U. Flaecher, M. G. Green, P. S. Jackson, T. R. McMahon,
S. Ricciardi, F. Salvatore, M. A. Winter
*University of London, Royal Holloway and Bedford New College, Egham, Surrey TW20 0EX,
United Kingdom*

D. Brown, C. L. Davis

University of Louisville, Louisville, KY 40292, USA

J. Allison, N. R. Barlow, R. J. Barlow, P. A. Hart, M. C. Hodgkinson, G. D. Lafferty, A. J. Lyon,
J. C. Williams
University of Manchester, Manchester M13 9PL, United Kingdom

A. Farbin, W. D. Hulsbergen, A. Jawahery, D. Kovalskyi, C. K. Lae, V. Lillard, D. A. Roberts
University of Maryland, College Park, MD 20742, USA

G. Blaylock, C. Dallapiccola, K. T. Flood, S. S. Hertzbach, R. Kofler, V. B. Koptchev, T. B. Moore,
S. Saremi, H. Staengle, S. Willocq
University of Massachusetts, Amherst, MA 01003, USA

¹Now at Department of Physics, University of Warwick, Coventry, United Kingdom

R. Cowan, G. Sciolla, S. J. Sekula, F. Taylor, R. K. Yamamoto

Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, MA 02139, USA

D. J. J. Mangeol, P. M. Patel, S. H. Robertson

McGill University, Montréal, QC, Canada H3A 2T8

A. Lazzaro, V. Lombardo, F. Palombo

Università di Milano, Dipartimento di Fisica and INFN, I-20133 Milano, Italy

J. M. Bauer, L. Cremaldi, V. Eschenburg, R. Godang, R. Kroeger, J. Reidy, D. A. Sanders, D. J. Summers,
H. W. Zhao

University of Mississippi, University, MS 38677, USA

S. Brunet, D. Côté, P. Taras

Université de Montréal, Laboratoire René J. A. Lévesque, Montréal, QC, Canada H3C 3J7

H. Nicholson

Mount Holyoke College, South Hadley, MA 01075, USA

N. Cavallo,² F. Fabozzi,² C. Gatto, L. Lista, D. Monorchio, P. Paolucci, D. Piccolo, C. Sciacca

Università di Napoli Federico II, Dipartimento di Scienze Fisiche and INFN, I-80126, Napoli, Italy

M. Baak, H. Bulten, G. Raven, H. L. Snoek, L. Wilden

*NIKHEF, National Institute for Nuclear Physics and High Energy Physics, NL-1009 DB Amsterdam,
The Netherlands*

C. P. Jessop, J. M. LoSecco

University of Notre Dame, Notre Dame, IN 46556, USA

T. Allmendinger, K. K. Gan, K. Honscheid, D. Hufnagel, H. Kagan, R. Kass, T. Pulliam, A. M. Rahimi,
R. Ter-Antonyan, Q. K. Wong

Ohio State University, Columbus, OH 43210, USA

J. Brau, R. Frey, O. Igonkina, C. T. Potter, N. B. Sinev, D. Strom, E. Torrence

University of Oregon, Eugene, OR 97403, USA

F. Colecchia, A. Dorigo, F. Galeazzi, M. Margoni, M. Morandin, M. Posocco, M. Rotondo, F. Simonetto,
R. Stroili, G. Tiozzo, C. Voci

Università di Padova, Dipartimento di Fisica and INFN, I-35131 Padova, Italy

M. Benayoun, H. Briand, J. Chauveau, P. David, Ch. de la Vaissière, L. Del Buono, O. Hamon,
M. J. J. John, Ph. Leruste, J. Malcles, J. Ocariz, M. Pivk, L. Roos, S. T'Jampens, G. Therin

*Universités Paris VI et VII, Laboratoire de Physique Nucléaire et de Hautes Energies, F-75252 Paris,
France*

P. F. Manfredi, V. Re

Università di Pavia, Dipartimento di Elettronica and INFN, I-27100 Pavia, Italy

²Also with Università della Basilicata, Potenza, Italy

P. K. Behera, L. Gladney, Q. H. Guo, J. Panetta
University of Pennsylvania, Philadelphia, PA 19104, USA

C. Angelini, G. Batignani, S. Bettarini, M. Bondioli, F. Bucci, G. Calderini, M. Carpinelli, F. Forti,
M. A. Giorgi, A. Lusiani, G. Marchiori, F. Martinez-Vidal,³ M. Morganti, N. Neri, E. Paoloni, M. Rama,
G. Rizzo, F. Sandrelli, J. Walsh

Università di Pisa, Dipartimento di Fisica, Scuola Normale Superiore and INFN, I-56127 Pisa, Italy

M. Haire, D. Judd, K. Paick, D. E. Wagoner
Prairie View A&M University, Prairie View, TX 77446, USA

N. Danielson, P. Elmer, Y. P. Lau, C. Lu, V. Miftakov, J. Olsen, A. J. S. Smith, A. V. Telnov
Princeton University, Princeton, NJ 08544, USA

F. Bellini, G. Cavoto,⁴ R. Faccini, F. Ferrarotto, F. Ferroni, M. Gaspero, L. Li Gioi, M. A. Mazzoni,
S. Morganti, M. Pierini, G. Piredda, F. Safai Tehrani, C. Voena

Università di Roma La Sapienza, Dipartimento di Fisica and INFN, I-00185 Roma, Italy

S. Christ, G. Wagner, R. Waldi
Universität Rostock, D-18051 Rostock, Germany

T. Adye, N. De Groot, B. Franek, N. I. Geddes, G. P. Gopal, E. O. Olaiya
Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, United Kingdom

R. Aleksan, S. Emery, A. Gaidot, S. F. Ganzhur, P.-F. Giraud, G. Hamel de Monchenault, W. Kozanecki,
M. Legendre, G. W. London, B. Mayer, G. Schott, G. Vasseur, Ch. Yèche, M. Zito
DSM/Dapnia, CEA/Saclay, F-91191 Gif-sur-Yvette, France

M. V. Purohit, A. W. Weidemann, J. R. Wilson, F. X. Yumiceva
University of South Carolina, Columbia, SC 29208, USA

D. Aston, R. Bartoldus, N. Berger, A. M. Boyarski, O. L. Buchmueller, R. Claus, M. R. Convery,
M. Cristinziani, G. De Nardo, D. Dong, J. Dorfan, D. Dujmic, W. Dunwoodie, E. E. Elsen, S. Fan,
R. C. Field, T. Glanzman, S. J. Gowdy, T. Hadig, V. Halyo, C. Hast, T. Hryn'ova, W. R. Innes,
M. H. Kelsey, P. Kim, M. L. Kocian, D. W. G. S. Leith, J. Libby, S. Luitz, V. Luth, H. L. Lynch,
H. Marsiske, R. Messner, D. R. Muller, C. P. O'Grady, V. E. Ozcan, A. Perazzo, M. Perl, S. Petrak,
B. N. Ratcliff, A. Roodman, A. A. Salnikov, R. H. Schindler, J. Schwiening, G. Simi, A. Snyder, A. Soha,
J. Stelzer, D. Su, M. K. Sullivan, J. Va'vra, S. R. Wagner, M. Weaver, A. J. R. Weinstein,
W. J. Wisniewski, M. Wittgen, D. H. Wright, A. K. Yarritu, C. C. Young
Stanford Linear Accelerator Center, Stanford, CA 94309, USA

P. R. Burchat, A. J. Edwards, T. I. Meyer, B. A. Petersen, C. Roat
Stanford University, Stanford, CA 94305-4060, USA

S. Ahmed, M. S. Alam, J. A. Ernst, M. A. Saeed, M. Saleem, F. R. Wappler
State University of New York, Albany, NY 12222, USA

³Also with IFIC, Instituto de Física Corpuscular, CSIC-Universidad de Valencia, Valencia, Spain

⁴Also with Princeton University, Princeton, USA

W. Bugg, M. Krishnamurthy, S. M. Spanier
University of Tennessee, Knoxville, TN 37996, USA

R. Eckmann, H. Kim, J. L. Ritchie, A. Satpathy, R. F. Schwitters
University of Texas at Austin, Austin, TX 78712, USA

J. M. Izen, I. Kitayama, X. C. Lou, S. Ye
University of Texas at Dallas, Richardson, TX 75083, USA

F. Bianchi, M. Bona, F. Gallo, D. Gamba
Università di Torino, Dipartimento di Fisica Sperimentale and INFN, I-10125 Torino, Italy

L. Bosisio, C. Cartaro, F. Cossutti, G. Della Ricca, S. Dittongo, S. Grancagnolo, L. Lanceri, P. Poropat,⁵
L. Vitale, G. Vuagnin
Università di Trieste, Dipartimento di Fisica and INFN, I-34127 Trieste, Italy

R. S. Panvini
Vanderbilt University, Nashville, TN 37235, USA

Sw. Banerjee, C. M. Brown, D. Fortin, P. D. Jackson, R. Kowalewski, J. M. Roney, R. J. Sobie
University of Victoria, Victoria, BC, Canada V8W 3P6

H. R. Band, B. Cheng, S. Dasu, M. Datta, A. M. Eichenbaum, M. Graham, J. J. Hollar, J. R. Johnson,
P. E. Kutter, H. Li, R. Liu, A. Mihalyi, A. K. Mohapatra, Y. Pan, R. Prepost, P. Tan, J. H. von
Wimmersperg-Toeller, J. Wu, S. L. Wu, Z. Yu
University of Wisconsin, Madison, WI 53706, USA

M. G. Greene, H. Neal
Yale University, New Haven, CT 06511, USA

⁵Deceased

1 INTRODUCTION

A theoretically clean measurement of the angle $\gamma = \arg(-V_{ud}V_{ub}^*/V_{cd}V_{cb}^*)$ can be obtained from the study of $B^- \rightarrow D^{(*)0}K^{(*)-}$ decays by exploiting the interference between the $b \rightarrow c\bar{s}$ and $b \rightarrow u\bar{s}$ decay amplitudes [1]. The method originally proposed by Gronau, Wyler and London is based on the interference between $B^- \rightarrow D^0K^-$ and $B^- \rightarrow \bar{D}^0K^-$ when the D^0 and \bar{D}^0 decay to CP eigenstates.

We define the ratios R and $R_{CP\pm}$ of Cabibbo-suppressed to Cabibbo-favored branching fractions

$$R_{(CP\pm)} \equiv \frac{\mathcal{B}(B^- \rightarrow D_{(CP\pm)}^0 K^-) + \mathcal{B}(B^+ \rightarrow \bar{D}_{(CP\pm)}^0 K^+)}{\mathcal{B}(B^- \rightarrow D_{(CP\pm)}^0 \pi^-) + \mathcal{B}(B^+ \rightarrow \bar{D}_{(CP\pm)}^0 \pi^+)} \quad (1)$$

with the neutral D meson reconstructed in non- CP (D^0) or CP -even/odd eigenstates ($D_{CP\pm}^0$) channels, and the direct CP asymmetry

$$A_{CP\pm} \equiv \frac{\mathcal{B}(B^- \rightarrow D_{CP\pm}^0 K^-) - \mathcal{B}(B^+ \rightarrow D_{CP\pm}^0 K^+)}{\mathcal{B}(B^- \rightarrow D_{CP\pm}^0 K^-) + \mathcal{B}(B^+ \rightarrow D_{CP\pm}^0 K^+)} . \quad (2)$$

Neglecting the $D^0 - \bar{D}^0$ mixing and the ratio $r_\pi = A(B^- \rightarrow \bar{D}^0\pi^-)/A(B^- \rightarrow D^0\pi^-)$ of the amplitudes of the $B^- \rightarrow \bar{D}^0\pi^-$ and $B^- \rightarrow D^0\pi^-$ processes ($|r_\pi| < 0.02$), we can write $R_\pm \equiv R_{CP\pm}/R = 1 + r^2 \pm 2r \cos \delta \cos \gamma$ and $A_{CP\pm} = \pm 2r \sin \delta \sin \gamma / (1 + r^2 \pm 2r \cos \delta \cos \gamma)$. Here $r = |A(B^- \rightarrow \bar{D}^0K^-)/A(B^- \rightarrow D^0K^-)|$ is the magnitude of the ratio of the amplitudes for the processes $B^- \rightarrow \bar{D}^0K^-$ and $B^- \rightarrow D^0K^-$, expected from theory to be about 0.1 – 0.2, and δ is the relative strong phase between these two amplitudes [1]. The measurement of R_\pm and $A_{CP\pm}$ allows one to constrain the three unknowns r , δ and the CKM angle γ . In this paper we present the measurement of R_\pm and $A_{CP\pm}$.

2 THE BABAR DETECTOR AND DATASET

The measurements reported in this paper have been obtained from a sample of about 214 million $\Upsilon(4S)$ decays to $B\bar{B}$ pairs collected with the *BABAR* detector at the PEP-II asymmetric-energy B factory. The *BABAR* detector is described in detail elsewhere [2]. Charged-particle tracking is provided by a five-layer silicon vertex tracker (SVT) and a 40-layer drift chamber (DCH). For charged-particle identification, ionization energy loss in the DCH and SVT, and Cherenkov radiation detected in a ring-imaging device (DIRC) are used. Photons are identified by the electromagnetic calorimeter (EMC), which comprises 6580 thallium-doped CsI crystals. These systems are mounted inside a 1.5-T solenoidal superconducting magnet. The segmented flux return, including endcaps, is instrumented with resistive plate chambers (IFR) for muon and K_L^0 identification. We use the GEANT [3] software to simulate interactions of particles traversing the detector, taking into account the varying accelerator and detector conditions.

3 ANALYSIS METHOD

We reconstruct $B^- \rightarrow D^0 h^-$ decays, where the prompt track h^- is a kaon or a pion. Reference to the charge-conjugate state is implied here and throughout the text unless otherwise stated. Candidates for D^0 are reconstructed in the CP -even eigenstates $\pi^-\pi^+$ and K^-K^+ , in the CP -odd eigenstate $K_S^0\pi^0$, and in the non- CP flavor eigenstate $K^-\pi^+$. K_S^0 candidates are selected in the $\pi^-\pi^+$ channel.

The prompt particle h^- is required to have momentum greater than 1.4 GeV/ c . Particle ID information from the drift chamber and, when available, from the DIRC must be consistent with the kaon hypothesis for the K meson candidate in all D^0 modes and with the pion hypothesis for the π^\pm meson candidates in the $D^0 \rightarrow \pi^- \pi^+$ mode. For the prompt track to be identified as a pion or a kaon, we require that at least five Cherenkov photons are detected to insure a good measurement of the Cherenkov angle. We reject a candidate track if its Cherenkov angle is not within 3σ of the expected value for either the kaon or pion mass hypothesis. We also reject candidate tracks that are identified as electrons by the DCH and the EMC or as muons by the DCH and the IFR.

Photon candidates are clusters in the EMC that are not matched to any charged track, have a raw energy greater than 30 MeV and lateral shower shape consistent with the expected pattern of energy deposit from an electromagnetic shower. Photon pairs with invariant mass within the range 115–150 MeV/ c^2 ($\sim 3\sigma$) and total energy greater than 200 MeV are considered π^0 candidates. To improve the momentum resolution, the π^0 candidates are kinematically fit with their mass constrained to the nominal π^0 mass [4].

Neutral kaons are reconstructed from pairs of oppositely charged tracks with the invariant mass within 10 MeV ($\sim 3\sigma$) from the nominal K^0 mass. We also require that the ratio between the flight length distance in the plane transverse to the beams direction and its uncertainty is greater than 3.

The invariant mass of a D^0 candidate, $m(D^0)$, must be within 3σ of the D^0 mass. The D^0 mass resolution σ is about 7.5 MeV in the $K^-\pi^+$, K^-K^+ and $\pi^-\pi^+$ modes, and about 21 MeV in the $K_S^0\pi^0$ mode. Selected D^0 candidates are fitted with a constraint to the nominal D^0 mass.

We reconstruct B meson candidates by combining a D^0 candidate with a track h^- . For the $K^-\pi^+$ mode, the charge of the track h^- must match that of the kaon from the D^0 meson decay. We select B meson candidates by using the beam-energy-substituted mass $m_{\text{ES}} = \sqrt{(E_i^{*2}/2 + \mathbf{p}_i \cdot \mathbf{p}_B)^2/E_i^2 - p_B^2}$ and the energy difference $\Delta E = E_B^* - E_i^*/2$, where the subscripts i and B refer to the initial e^+e^- system and the B candidate respectively, and the asterisk denotes the center-of-mass (CM) ($\Upsilon(4S)$) frame. The m_{ES} distributions for $B^- \rightarrow D^0 h^-$ signal events are Gaussian distributions centered at the B mass with a resolution of 2.6 MeV/ c^2 , which does not depend on the decay mode or on the nature of the prompt track. In contrast, the ΔE distributions depend on the mass assigned to the prompt track. We evaluate ΔE with the kaon mass hypothesis so that the distributions are centered near zero for $B^- \rightarrow D^0 K^-$ events and shifted, on average, by approximately 50 MeV for $B^- \rightarrow D^0 \pi^-$ events. The ΔE resolution depends on the momentum resolution for the D^0 meson and the prompt track h^- , and is typically 17 MeV for all the D^0 decay modes. All B candidates are selected with m_{ES} within 2.5σ of the mean value and with ΔE in the range $-0.15 < \Delta E < 0.18$ GeV.

To reduce background from continuum production of light quarks, we construct a Fisher discriminant based on the following quantities: (i) the scalar sum of the momenta of all charged and neutral particles (excluding the B decay products) flowing into nine concentric cones centered on the B candidate thrust axis in the CM frame; (ii) the normalized second Fox-Wolfram moment [5], $R_2 \equiv H_2/H_0$, where H_l is the l -order Fox-Wolfram moment of all the charged tracks and neutral clusters in the event; (iii) $|\cos \theta_T|$, where θ_T is the angle between the thrust axes of the B candidate and of the remaining charged tracks and neutral clusters, evaluated in the CM frame; (iv) $|\cos \theta_B|$, where θ_B is the polar angle of the B candidate in the CM frame; (v) $|\cos \theta_{\text{hel}}(D^0)|$, where $\theta_{\text{hel}}(D^0)$ is the angle between the direction of one of the decay products of the D^0 and the direction of flight of the B , in the D^0 rest frame. Each cone in (i) subtends an angle of 10° in the CM and is folded to combine the forward and the backward intervals. A cut on the value of the Fisher discriminant

rejects more than 90% of the continuum background while retaining 77% of the signal in the $K^-\pi^+$, K^-K^+ and $K_S^0\pi^0$ modes and 65% in the $\pi^-\pi^+$ channel.

Multiple $B^-\rightarrow D^0 h^-$ -candidates are found in about 4% of the events for the $K_S^0\pi^0$ and in less than 1% of the events for the other D^0 decays. In these events a χ^2 is constructed from $m(\pi^0)$ (for $K_S^0\pi^0$ only), $m(D^0)$, and m_{ES} and only the candidate with the smallest χ^2 is retained. The total reconstruction efficiencies, based on simulated signal events, are about 33%($K^-\pi^+$), 28%(K^-K^+), 26%($\pi^-\pi^+$) and 17%($K_S^0\pi^0$).

The main contributions to the $B\bar{B}$ background come from the processes $B\rightarrow D^*h$ ($h = \pi, K$), $B^-\rightarrow D^0\rho^-$ and mis-reconstructed $B^-\rightarrow D^0h^-$. For $D^0\rightarrow K^-K^+$, $D^0\rightarrow\pi^-\pi^+$ and $D^0\rightarrow K_S^0\pi^0$ decays, the peaking backgrounds $B^-\rightarrow K^-K^+K^-$, $B^-\rightarrow K^-\pi^+\pi^-$ and $B^-\rightarrow K_S^0\pi^0K^-$ must also be considered, since they have the same ΔE and m_{ES} distribution as the D^0K^- signal. Their yields are estimated from the existing measurements[4, 6] and subtracted from the $B^-\rightarrow D^0K^-$ signal yields.

For each D^0 decay mode an extended unbinned maximum-likelihood fit to the selected data events determines the signal and background yields n_i ($i = 1$ to M , where M is the total number of signal and background channels). Two kinds of signal events, $B^-\rightarrow D^0\pi^-$ and $B^-\rightarrow D^0K^-$, are considered, and four kinds of backgrounds: candidates selected either from continuum or from $B\bar{B}$ events, in which the prompt track is either a pion or a kaon.

The input variables to the fit are ΔE and a particle identification probability for the prompt track based on the Cherenkov angle θ_C , the momentum p and the polar angle θ of the track. The extended likelihood function \mathcal{L} is defined as

$$\mathcal{L} = \exp\left(-\sum_{i=1}^M n_i\right) \prod_{j=1}^N \left[\sum_{i=1}^M n_i \mathcal{P}_i(\Delta E, \theta_C; \vec{\alpha}_i) \right], \quad (3)$$

where N is the total number of observed events. The M functions $\mathcal{P}_i(\Delta E, \theta_C; \vec{\alpha}_i)$ are the probability density functions (PDFs) for the variables $\Delta E, \theta_C$, given the set of parameters $\vec{\alpha}_i$. Since these two quantities are sufficiently uncorrelated, their probability density functions are evaluated as a product $\mathcal{P}_i = \mathcal{P}_i(\Delta E; \vec{\alpha}_i) \times \mathcal{P}_i(\theta_C; \vec{\alpha}_i)$.

The ΔE distribution for $B^-\rightarrow D^0K^-$ signal events is parametrized with a Gaussian function. The ΔE distribution for $B^-\rightarrow D^0\pi^-$ is parametrized with the same Gaussian used for $B^-\rightarrow D^0K^-$ with a relative shift of the mean, computed event by event as a function of the prompt track momentum, arising from the wrong mass assignment to the prompt track. The offset and width of the Gaussian are kept floating in the fit and are determined from data together with the yields.

The ΔE distribution for the continuum background is parametrized with a linear function whose slope is determined from off-resonance data. The ΔE distribution for the $B\bar{B}$ background is empirically parametrized with the sum of a Gaussian and an exponential function when the prompt track is a pion, and with an exponential function when the prompt track is a kaon. The parameters are determined from simulated events.

The particle identification PDF is obtained from a pure control sample of kaons and pions produced in the decay chain $D^{*+}\rightarrow D^0\pi^+$ ($D^0\rightarrow K^-\pi^+$), selected using kinematical information only, without any inputs from the *BABAR* particle identification system. The parametrization of the particle identification PDF is performed by fitting with a Gaussian distribution the background-subtracted distribution of the difference between the reconstructed and expected Cherenkov angles of the selected kaons and pions.

4 PHYSICS RESULTS AND SYSTEMATIC STUDIES

The results of the fit are summarized in Table 1. Figure 1 shows the distributions of ΔE for the $K^-\pi^+$, $CP+$ and $CP-$ modes after enhancing the $B \rightarrow D^0 K$ purity by requiring that the prompt track be consistent with the kaon hypothesis. This requirement is about 95% efficient for the $B^- \rightarrow D^0 K^-$ signal while retaining only 4% of the $B^- \rightarrow D^0 \pi^-$ candidates. The projection of a likelihood fit, modified to take into account the tighter selection criteria, is overlaid in the figure.

Table 1: Results of the $B^- \rightarrow D^0 K^-$ and $B^- \rightarrow D^0 \pi^-$ yields from the maximum-likelihood fit on data.

D^0 mode	$N(B \rightarrow D^0 \pi)$	$N(B \rightarrow D^0 K)$	$N(B^- \rightarrow D^0 K^-)$	$N(B^+ \rightarrow \bar{D}^0 K^+)$
$K^-\pi^+$	11930 ± 120	897 ± 34	441 ± 24	456 ± 25
K^-K^+	1093 ± 37	75^{+13}_{-12}	54^{+10}_{-9}	22^{+8}_{-7}
$\pi^-\pi^+$	345 ± 22	18 ± 7	12 ± 5	7^{+5}_{-4}
$K_S^0\pi^0$	1248 ± 40	76^{+13}_{-12}	46^{+10}_{-9}	30^{+9}_{-8}

The double ratios R_{\pm} are computed by scaling the ratios of the numbers of $B^- \rightarrow D^0 K^-$ and $B^- \rightarrow D^0 \pi^-$ mesons by correction factors (ranging from 0.997 to 1.020 depending on the D^0 mode) that account for small differences in the efficiency between the $B^- \rightarrow D^0 K^-$ and $B^- \rightarrow D^0 \pi^-$ selections, estimated with simulated signal samples. The results are listed in Table 2.

The direct CP asymmetries $A_{CP\pm}$ for the $B^\pm \rightarrow D_{CP\pm}^0 K^\pm$ decays are calculated from the measured yields of positive and negative charged meson decays and the results are reported in Table 2.

Table 2: Measured double branching fraction ratios R_{\pm} and CP asymmetries $A_{CP\pm}$ for different D^0 decay modes. The first error is statistical, the second is systematic.

D^0 decay mode	R_{CP}/R	A_{CP}
K^-K^+	$0.92 \pm 0.16 \pm 0.07$	$0.43 \pm 0.16 \pm 0.09$
$\pi^-\pi^+$	$0.70 \pm 0.29 \pm 0.09$	$0.27 \pm 0.40 \pm 0.09$
CP -even combined	$0.87 \pm 0.14 \pm 0.06$	$0.40 \pm 0.15 \pm 0.08$
$K_S^0\pi^0$	$0.80 \pm 0.14 \pm 0.08$	$0.21 \pm 0.17 \pm 0.07$

Systematic uncertainties in the double ratios R_{\pm} and in the CP asymmetries $A_{CP\pm}$ arise primarily from uncertainties in signal yields due to the estimate of the peaking backgrounds and from the imperfect knowledge of the PDF shapes. The systematic uncertainty associated to peaking backgrounds is evaluated by taking into account the uncertainties on their branching fractions and by allowing for Poisson fluctuations of their yields in the selected data sample. The estimated yields are 29 ± 7 ($B^- \rightarrow K^- K^+ K^-$), 4 ± 4 ($B^- \rightarrow K^- \pi^+ \pi^-$) and $0.0^{+5.6}_{-0.0}$ ($B^- \rightarrow K_S^0 \pi^0 K^-$). Possible CP asymmetries up to 30% in their yields are also taken into account. The parameters of the PDFs that are fixed in the nominal fit are varied by $\pm 1\sigma$ and the difference in the signal yields is taken as a systematic uncertainty.

The uncertainties in the branching fractions of the channels contributing to the $B\bar{B}$ background have been taken into account. The correlations between the different sources of systematic errors, when non-negligible, are considered. An upper limit on intrinsic detector charge bias due to acceptance, tracking, and particle identification efficiency has been obtained from the measured asymmetries in the processes $B^- \rightarrow D^0 [\rightarrow K^-\pi^+] h^-$ and $B^- \rightarrow D_{CP\pm}^0 \pi^-$, where CP violation is expected to be negligible. This limit (± 0.04) has been added in quadrature to the total systematic uncertainty on the CP asymmetry.

5 SUMMARY

In conclusion, we have reconstructed $B^- \rightarrow D^0 K^-$ decays with D^0 mesons decaying to non- CP ($K^-\pi^+$), CP -even ($K^-K^+, \pi^-\pi^+$) and CP -odd ($K_s^0\pi^0$) eigenstates. We have measured the CP asymmetries $A_{CP+} = 0.40 \pm 0.15(\text{stat}) \pm 0.08(\text{syst})$, $A_{CP-} = 0.21 \pm 0.17(\text{stat}) \pm 0.07(\text{syst})$, and the double ratio of branching fractions $R_+ = 0.87 \pm 0.14(\text{stat}) \pm 0.06(\text{syst})$, $R_- = 0.80 \pm 0.14(\text{stat}) \pm 0.08(\text{syst})$. These results improve the previous existing measurements from *BABAR* [7]. All results presented in this document are preliminary.

6 ACKNOWLEDGMENTS

We are grateful for the extraordinary contributions of our PEP-II colleagues in achieving the excellent luminosity and machine conditions that have made this work possible. The success of this project also relies critically on the expertise and dedication of the computing organizations that support *BABAR*. The collaborating institutions wish to thank SLAC for its support and the kind hospitality extended to them. This work is supported by the US Department of Energy and National Science Foundation, the Natural Sciences and Engineering Research Council (Canada), Institute of High Energy Physics (China), the Commissariat à l’Energie Atomique and Institut National de Physique Nucléaire et de Physique des Particules (France), the Bundesministerium für Bildung und Forschung and Deutsche Forschungsgemeinschaft (Germany), the Istituto Nazionale di Fisica Nucleare (Italy), the Foundation for Fundamental Research on Matter (The Netherlands), the Research Council of Norway, the Ministry of Science and Technology of the Russian Federation, and the Particle Physics and Astronomy Research Council (United Kingdom). Individuals have received support from CONACyT (Mexico), the A. P. Sloan Foundation, the Research Corporation, and the Alexander von Humboldt Foundation.

References

- [1] M. Gronau and D. Wyler, Phys. Lett. **B265**, 172 (1991); M. Gronau and D. London, Phys. Lett. **B253** 483 (1991); D. Atwood, I. Dunietz and A. Soni, Phys. Rev. Lett. **78**, 3257 (1997); A. Giri, Y. Grossman, A. Soffer, J. Zupan Phys. Rev. **D68** 054018 (2003).
- [2] *BABAR* Collaboration, B. Aubert *et al.*, Nucl. Instr. and Methods **A479** 1 (2002).
- [3] GEANT4 Collaboration, S. Agostinelli *et al.*, Nucl. Instr. and Methods **A506** 250 (2003).
- [4] Particle Data Group, S. Eidelman *et al.*, Phys. Lett. **B592** 1 (2004).
- [5] G.C. Fox and S. Wolfram, Phys. Rev. Lett. **41** 1581 (1978).

- [6] Belle Collaboration, K. Abe *et al.*, Phys. Rev. **D65** 092005 (2002); *BABAR* Collaboration, B. Aubert *et al.*, hep-ex/0308065, submitted to Phys. Rev. Lett. .
- [7] *BABAR* Collaboration, B. Aubert *et al.*, Phys. Rev. Lett. **92** 202002 (2004).

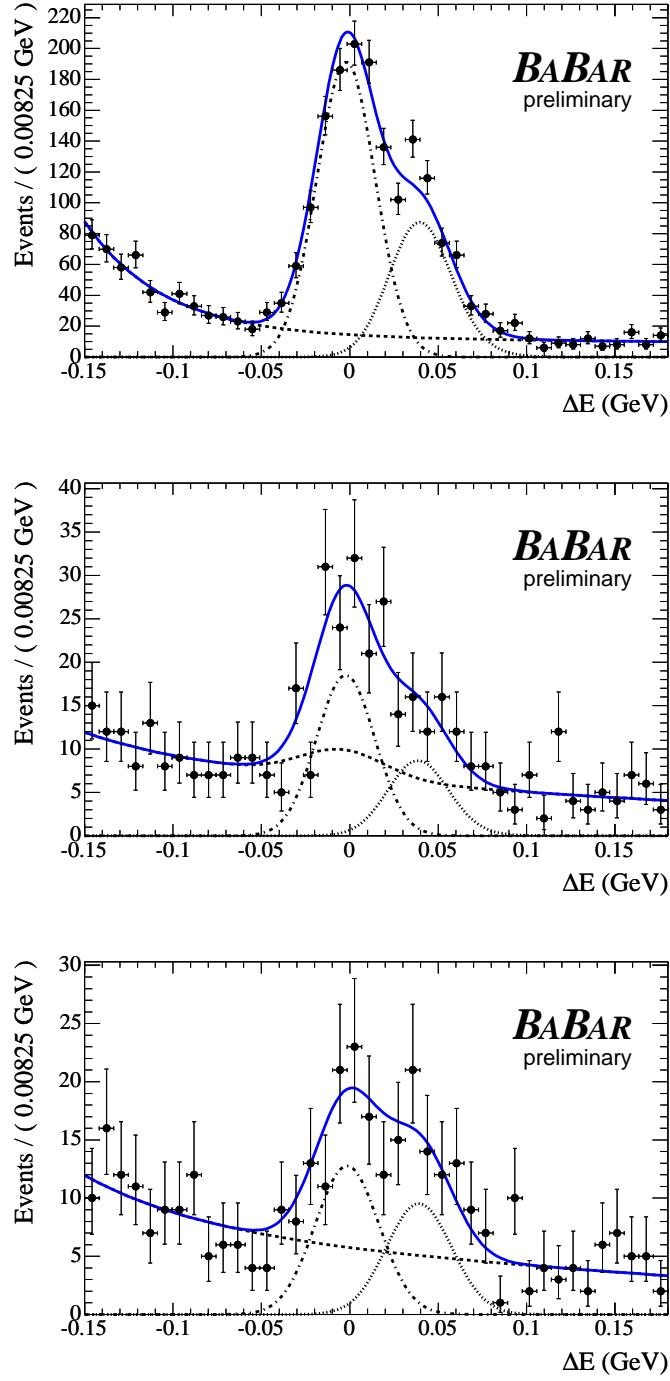


Figure 1: ΔE distributions of $B^- \rightarrow D^0 h^-$ candidates, where a charged kaon mass hypothesis is assumed for h . Events are enhanced in $B^- \rightarrow D^0 K^-$ purity by requiring the Cherenkov angle of the track h to be within 2σ of the kaon hypothesis. Top: $B^- \rightarrow D^0 [K^- \pi^+] K^-$; middle: $B^- \rightarrow D_0^{(-)} [K^- K^+, \pi^- \pi^+] K^-$; bottom: $B^- \rightarrow D_0^{(-)} [K_S^0 \pi^0] K^-$. Solid curves represent projections of the maximum likelihood fit; dashed-dotted, dotted and dashed curves represent the $B \rightarrow D^0 K$, $B \rightarrow D^0 \pi$ and background contributions.